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**Communications****Spectrum**

Authors Martyn Roetter, D.Phil., and Alan Pearce, Ph.D., argue that leading U.S. wireless companies are touting a meaningless and misleading measure of the efficiency of their use of scarce spectrum. Moreover, Roetter and Pearce express dismay that the industry leaders have not seen fit to respond to severe criticism of the metric from qualified professionals, including themselves. Their article details the “spurious” nature of the metric and suggests the FCC discard claims based on its use. Furthermore, the authors propose an industrywide initiative to develop an honest and credible spectrum efficiency metric.

## **The Mystery of the Spurious Spectrum Efficiency Metric: Why Are America’s Wireless Leaders Promoting a Meaningless Measure?**

BY MARTYN ROETTER, D.PHIL. AND ALAN PEARCE, PH.D.

**“T**he dog that didn’t bark” is an expression from a Sherlock Holmes mystery. It was an important clue that led to identifying the criminal. The killer entered and left the estate grounds one night,

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***Alan Pearce, Ph.D.** ([IAEpearce@aol.com](mailto:IAEpearce@aol.com)), a former chief economist of the FCC, helped launch an FCC investigation of Western Electric and the Bell System in 1972 that led to the antitrust suit that broke up AT&T in 1984. In 2004, Pearce assisted Cingular Wireless in its record \$41 billion acquisition of AT&T Wireless.*

but the guard dog did not bark an alarm at the intruder’s presence as expected. From this non-event Holmes reasoned that the dog must have known the killer. This clue led to Holmes’s solving the case.

There is an apt analogy concerning implications drawn from the curious silence and failure to “bark” or respond of the two leading U.S. wireless operators, Verizon and AT&T, as well as CTIA, the largest trade association representing U.S. wireless carriers. They have remained mute in the face of evidence that the metric on which they base assertions of the superior spectrum efficiency of Verizon and AT&T, and the U.S. mobile sector, compared to other countries is fundamentally flawed. One does not have to be Sherlock Holmes, however, to deduce that the cause of their silence is an inability to defend their meretricious metric.

This silence, despite our multiple attempts to engage in productive dialogs about the important issue of spectrum efficiency, is also a clue to their attitudes about the openness, transparency, integrity, and reliability of the information they and their lobbyists present to the Federal Communications Commission and the U.S. public in order to support their assertions in matters of spectrum policy and regulation.

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Claims about spectrum efficiency are very pertinent today when operators are clamoring for additional spectrum. The metric Verizon and others have been using to justify assertions that they will soon exhaust their existing spectrum is bogus. Therefore it is imperative to formulate an honest metric so that decisions about the allocation and re-allocation of spectrum to mobile communication services to and, if necessary, from other uses are reached on the basis of the best possible and most credible evidence.

The meaningless claims of Verizon, the CTIA and their supporters about their best-in-class spectrum efficiency hinder efforts to determine whether U.S. mobile operators are in reality making the most effective use of the spectrum that has already been assigned to them, as well as of other techniques such as Wi-Fi offloading for handling rapidly rising volumes of mobile broadband traffic. The question of how much new spectrum mobile operators may need in the next few years is a serious one. Our point is not to deny that there may be such a need, but that its urgency and extent should be assessed on the basis of facts, not fantasies

### **How the Metric Doesn't Work**

The metric in question calculates spectrum efficiency in terms of subscribers per MHz, i.e., the total number of customers of a mobile operator (or of all the mobile operators in a country) divided by the average depth or quantity of spectrum in all the licenses held by the operator or assigned to all the operators in a country. This metric would have some value and meaning if, in fact, all of an operator's mobile customers, or all the mobile customers in a country—for example the 326 million mobile connections reported by the CTIA as of end-2012—shared the same frequencies, or had to compete to connect to the same access network capacity. But of course they do not.

The very purpose and genius of cellular technology on which the architecture of mobile networks is based is that it allows the same frequencies to be re-used many times within a country or within an individual license area in different cells. For example in the United States the average number of mobile customers or connections within a single cell sector, who therefore are sharing the same frequencies or the same wireless network capacity, is around 300. The fatal flaw in the metric for spectrum efficiency used to support their claims by Verizon, the CTIA, and others is that it assumes a mobile network structure in which frequencies are only used once within a country or within the entire footprint of an operator, whereas in reality they are re-used over and over again in different cells thousands or tens of thousands of times or even more depending on the size of the area or the country. The enormity of this flaw is

evident in the statistic that, according to the CTIA, as of end-2012 there were about 302,000 cell sites in the United States, or an average of just under 1,100 mobile customers per site. It is inconceivable that the two largest cellular operators Verizon and AT&T are unaware of this fact.

The results produced by application of the spectrum efficiency metric propagated by the leading U.S. wireless operators are strongly correlated with, although not solely determined by the size of the population covered by an operator's licenses or by the size of a country's population in the case of country comparisons. This metric is not related to and is not a remotely plausible surrogate for an ideal metric of spectrum efficiency that would reflect the capacity that an operator is able to deliver to its customers. This capacity can be expressed in terms of megabits per second (Mbps) per MHz-km<sup>2</sup>, i.e. the capacity per unit area (in square kilometers) that an operator can make available to its customers for every MHz in which it deploys mobile systems. Capacity within a cell is what determines the number of simultaneous users that an operator's network can serve in a cell and the speeds they will experience.

A plausible but still far from perfect surrogate for capacity based on numbers of subscribers per MHz would involve comparisons of customers and spectrum holdings between operators in the same country in the same license area, or between operators in different countries in similar license areas, i.e. urban locations with comparable population densities. The need to achieve maximum high spectrum efficiency is most acute to handle peak traffic volumes in dense urban areas and very crowded locations such as sports stadiums, malls, and airports.

Thanks to its strong correlation with demographics and not spectrum efficiency, the spurious metric favored by the largest U.S. mobile operators and the CTIA leads inevitably to the result that the two largest U.S. operators emerge as the most efficient users of spectrum, while the U.S. mobile sector overall is presented as more efficient than the mobile sector in other countries with substantially smaller populations. Evidence of the spurious nature of the results generated by use of their metric has been pointed out to the CTIA and to Verizon in a number of communications over the past 12 months, by direct email (to the CTIA in June 2012) and in an Information Age Economics (IAE) filing to the FCC<sup>1</sup> (in May 2012). The IAE submission stated, “We present additional evidence to reinforce an analysis included in an earlier filing by T-Mobile<sup>2</sup> which showed that VZW's [Verizon Wireless] calculation of spectral efficiencies produces a spurious and meaningless metric devoid of any value for comparing how efficiently different individual operators, or collectively all mobile operators in a country, are making use of the spectrum allocated to them.”

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<sup>1</sup> Information Age Economics, <http://apps.fcc.gov/ecfs/document/view?id=7021920798>.

<sup>2</sup> REPLY OF T-MOBILE, USA, INC. TO OPPOSITION TO PETITION TO DENY, Exhibit A, <http://apps.fcc.gov/ecfs/document/view?id=7021903695>

**The metric produces the finding that China as a country and China Mobile as an operator are more than three times as efficient as the U.S. mobile industry and Verizon.**

Furthermore use of the metric produces the finding that China as a country and China Mobile as an operator would be characterized as more than three times as efficient as the U.S. mobile industry and Verizon, respectively. These findings, that of course have not been included in the selective findings presented to date by the CTIA and Verizon, are as devoid of credibility as are theirs, for example that U.S. operators are over eight times more efficient than their Canadian counterparts<sup>3</sup>. Their selective findings only compare U.S. operators with, for the most part, less extensive coverage than AT&T and Verizon, and the United States with countries that have much smaller populations.

Astonishing results, defying commonsense as well as engineering credibility, including those just mentioned, are produced by use of the Verizon/CTIA metric, as illustrated in the following Tables. They include

<sup>3</sup> Sources: "Investment + Commitment + Spectrum = Benefits for Wireless Consumers," <http://blog.ctia.org/2012/05/31/benefits/>, and [http://files.ctia.org/pdf/081211.Spectrum\\_Availability\\_Chart.pdf](http://files.ctia.org/pdf/081211.Spectrum_Availability_Chart.pdf)

examples—from India and China—that have not been presented by the advocates of this metric, in addition to the other countries that have been used heretofore to support unjustified assertions of the global superiority of the mobile sector in the United States and the superiority of Verizon and AT&T within the United States. These additional examples convey that the United States and Verizon lag well behind the leaders in a truly global comparison. Assessed along with the numbers touted by AT&T, Verizon and CTIA, however, they demonstrate that the underlying metric is meaningless.

The findings produced by use of this metric are astounding. If they were believable and thought to be credible by the U.S.-based users of the metric then they should all be rushing off to Asia—like the U.S. and European companies who flocked to Japan to learn about its high quality manufacturing techniques in the 1970s and 1980s—to identify and bring back the ingredients that enable the extraordinary global superiority of the Indians and Chinese in the efficiency of their uses of spectrum. Among the most absurd of these findings are:

- In North America, Canada is less than one eighth as efficient as the United States and Mexico is over 3.5 times more efficient than Canada;
- us
- Mexico is almost twice as efficient as Germany;
- India is over 60 percent more efficient than China, which is itself over three times more efficient than the United States, and China Mobile is similarly over 3 times more efficient than Verizon;
- India is over 11 times more efficient than Japan.

Table 1a: Spectrum Efficiency According to the Spurious Verizon/CTIA Metric<sup>1</sup>

End-2011	U.S.	Japan	Germany	U.K.	France	Italy	Canada	Spain	Korea	Mexico	China	India
Mobile Subs., million	331.6	126.1	114.1	76.9	64.3	92.4	26.6	58.1	52.5	93.2	1,000	900
MHz, million	409.5	347	615	375	375	375	270	625	270	260	400	220
SSMA	1.0	0.449	0.229	0.253	0.212	0.304	0.122	0.115	0.240	0.443	<b>3.087</b>	<b>5.052</b>

Sources: Adapted from CTIA and Information Age Economics (IAE) estimates – figures for all countries except China and India are taken from CTIA documents.

para><sup>1</sup> Notes: MHz = Spectrum assigned for Commercial use – this amount changes as more spectrum is assigned and in some countries the current (mid-2013) amounts have increased significantly since end-2011; SSMA= Spectrum efficiency defined as "Subscribers Served per MHz of Spectrum Assigned", normalized to the U.S. at 809,755 subscribers/MHz – a higher number indicates greater spectrum efficiency.

Table 1 b: Spectrum Efficiency According to the Spurious Verizon/CTIA Metric <sup>1</sup>

End-2011	Verizon Wireless	China Mobile	Ratio China Mobile/VZW
Subscribers, million	109	649.6	5.96
Spectrum Depth, MHz	89	165	1.85
SSMA, million	1.225	3.937	3.21

*Sources: Operator reports and IAE*

The flawed character of the Verizon/CTIA metric can be demonstrated by another example based on the CTIA's own figures from Table 1a above. If spectrum efficiency is calculated for a combination of three of the larger countries in the European Union (Unifrit – comprising U.K./France/Italy), then since the assigned spectrum is the same for all three countries it will also be 375 MHz for their combination. The total number of mobile subscribers in the three countries is 233.6 million. Therefore, according to the CTIA, the spectrum efficiency of Unifrit would be 0.623 normalized to that of the United States, i.e., miraculously, it would be between two to three times higher than the efficiencies of its individual national components, although the networks involved are exactly the same. An honest measure of spectrum efficiency would produce a result that is a weighted average *and not an addition* of the efficiencies of the individual networks being evaluated.

Disturbingly, the same metric has recently been employed in a report published by the McDonough School of Business at Georgetown University, "The Economic Implications of Restricting Spectrum Purchases in the Incentive Auctions." The findings of this report support the positions of Verizon and AT&T that restrictions on their eligibility to bid in future Incentive Auctions of 600 MHz licenses would be harmful, and therefore unjustified, because these licenses would then be acquired by allegedly "less efficient" U.S. mobile operators. As a result, potential substantial economic benefits would not be generated and numbers of potential jobs would not be created. This report has been filed with the FCC<sup>4</sup>.

The fundamentally flawed character and irrelevance of the spurious spectrum efficiency metric used in the McDonough report as the basis of the assertion that Verizon and AT&T are the two most efficient users of spectrum in the United States, has been explained in an email sent to Professor Mayo, Dean of the McDonough School of Business, who wrote the Introduction to the report. This email was also filed a week later with the FCC.<sup>5</sup>

Despite the several direct and public attempts just outlined, neither the CTIA, nor the two largest U.S. mobile operators, nor the McDonough School, have yet seen fit to "bark" in reaction to these "intrusions and rebuttals" on their findings. They have offered no justification for their initial and continuing use of a false metric.

<sup>4</sup> <http://apps.fcc.gov/ecfs/document/view?id=7022309583>.

<sup>5</sup> <http://apps.fcc.gov/ecfs/document/view?id=7022312455>.

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Use of this flawed metric is not just an academic exercise in which there may be reasonable differences of opinion based on plausible alternative judgments. This metric violates the core precept of cellular technology on which the CTIA and mobile operators have built their existence and ability to deliver value to society and the economy. Fatally flawed calculations, based on this metric are being invoked in attempts to influence the outcomes of regulatory reviews conducted by the FCC that will have a significant impact on the competitiveness of the U.S. mobile broadband market.

Verizon provided a glaring example of the deceptive use of the Verizon/CTIA metric to make a claim for its own superiority in a filing to the FCC in March, 2012 in support of its transactions to acquire spectrum licenses from four cable operators (Comcast, Time Warner Cable, BrightHouse and Cox).<sup>6</sup> These spectrum transactions were part of the formation of the Verizon/cable cartel that was approved by the FCC and the Department of Justice in August, 2012.

In further support of our position we recently came across independent confirmation of the refutation of this metric of spectrum efficiency from Canada that preceded our own awareness of the issue. In April 2011 one of the three leading mobile operators in Canada,

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<sup>6</sup> "Verizon Wireless is today, and post-transaction will continue to be, one of the most efficient users of spectrum. Verizon Wireless currently serves its industry-leading 109 million wireless customer connections using an average of 89 MHz nationwide, with each megahertz of spectrum serving on average 1.23 million customer connections. Post-transaction, these wireless connections would be served using an average of 109 MHz nationwide, with each megahertz of spectrum serving on average almost one million customer connections. Despite the claims of T-Mobile and others to the contrary, this usage makes Verizon Wireless the most spectrally efficient wireless provider currently, and the second most spectrally efficient provider post-transaction (second only to AT&T and tied with MetroPCS)," JOINT OPPOSITION TO PETITIONS TO DENY AND COMMENTS, Application of Cellco Partnership d/b/a Verizon Wireless and Spectrum Co., LLC For Consent To Assign Licenses – see page 23 at

<http://apps.fcc.gov/ecfs/document/view?id=7021899742>  
<http://apps.fcc.gov/ecfs/document/view?id=7021899744>



Bell Mobility, filed a Reply Comment with Industry Canada in its “Consultation on a Policy and Technical Framework for the 700 MHz Band and Aspects Related to Commercial Mobile Spectrum,” that objected to a report from a Vancouver-based consultant (the SeaBoard Group) using the metric that presented a finding that Canadian operators were much less efficient in their use of spectrum than their U.S. counterparts. Bell Mobility’s analysis concluded with a finding consistent with ours, *“Therefore the only conclusion one can draw, using SeaBoard’s calculation of the subscribers/MHz metric, is that it is a meaningless method of comparing spectral efficiency, between operators, when the underlying market sizes are so vastly different.”*<sup>7</sup>

### **Wanted: An Accurate Spectrum Efficiency Metric**

Reasonable conclusions about the intent of Verizon and AT&T and their supporters that can be drawn from their silence despite compelling evidence that the metric they have promoted and advocated in support of their positions in policy and regulatory matters include:

- (1) They are not interested in engaging in open and fact-based debates about controversial issues; and
- (2) They are hoping that continued repetition over time will lead to the useless metric becoming “accepted wisdom” despite its flaws.

<sup>7</sup> Reply Comments of Bell Mobility, April 2011, <http://tinyurl.com/mt9od3s>, see pp. 34-36.

The supporters of Verizon and AT&T include some who may be ideologically inclined (and therefore not swayed by evidence) to agree with Verizon’s and AT&T’s positions in all circumstances. They may also include others who, if not knowledgeable themselves about wireless networks, may assume, not unreasonably, that since these operators have deployed nationwide cellular networks they must understand how to measure spectrum efficiency in these networks fairly and on a sound engineering basis.

The questions of how to maximize spectrum efficiency and assess which operators are the best performers along this critical dimension, and how they achieve this superior performance, are essential elements in debates about critical issues in spectrum management policy, choices for spectrum allocations, assignments, and procedures for future spectrum policy and auctions. The largest U.S. mobile operators and their supporters are debasing the environment in which these debates are taking place by their silence in the face of the public and direct exposure of the fundamental flaw in the metric they use to calculate spectrum efficiency. They should apply their formidable engineering expertise and other capabilities toward developing a spectrum efficiency metric that will be widely accepted as a fair and practically implementable representation of performance along this dimension.

Since the spectrum used by these wireless giants is a public, not a private, resource they should be held to a higher standard than is manifest in their use of arguments and assertions, no matter how inaccurate, misleading, and unjustified in pursuit of their commercial business interests.